A 21st Century Approach to Reliability

Electrical Engineering

- Mark Law, Aristotle, Ebers, Fellow
- Toshi Nishida
- Scott Thompson, SEMI Technology, Fellow
- Gijs Bosman

Materials Science

- Steve Pearton – Ebers, Bardeen, Fellow
- Cammy Abernathy - Fellow
- Brent Gila
- Kevin Jones - Fellow

Chemical Engineering

- Fan Ren - Fellow

Post-Docs

- Michelle Griglione, Erin Patrick
- Nick Rudawski, Chih-Yang Chang

Students

- Erica Douglas, David Cheney
- Amit Gupta, Andy Koehler
- Nicole Rowsey, David Horton
- Hemant Rao, Ray Holzworth
- Patrick Whiting, Min Chu
- Danny Zeenberg, Weikai Xu
- Liu Lu, Tseng Sheng Kang
- Chien Fong Lo, Xiaotie Wang

GATOR Engineering
UNIVERSITY OF FLORIDA

Agenda and Logistics – May 5

- 12:00 Lunch – Buffet style
- 12:45 AFOSR Program Manager, Gregg Jessen – Perspectives
- 1:00 Bill Roesch, Industrial Perspective
- 1:30 MURI Overview (Mark Law)
- 2:00 Break
- 2:15 Device Testing and Insights
  - Effects of Source Field Plate and Pt-gate Metallization on HEMT Reliability Rob Finch (30 min)
  - Degradation of AlGaN/GaN HEMTs under DC and RF Stress Erica Douglas (30 min)
  - Tester Update by Dave Cheney (15 min)
- 3:30 Break
- 4:00 Electrical Characterization
  - Effects of Mechanical Stress on GaN HEMT Gate Current: Experiment, Mechanisms and Models Amit Gupta, Andy Koehler, Min Chu (30 min)
  - Low frequency noise characterization of RF stressed AlGaN/GaN HEMTS Hemant Rao and Gijs Bosman) (15 min)
  - Low frequency noise studies on AlGaN/GaN HEMTS with off-state stress beyond the critical voltage Weikai Xu and Gijs Bosman (15 min)
- 5:00 End
- 6:00 Dinner and Drinks, Napolitano's

Presentations at:
www.reliability.ece.ufl.edu

Dinner Logistics

- Buffet Dinner at Napolatano's

Agenda and Logistics – May 6

Presentations at:
www.reliability.ece.ufl.edu

- May 6, 2011
- 8:00 Continental Breakfast and Posters
- 9:00 Materials Characterization I
  - LEAP, TEM, and Interfacial Defects of AlGaN/GaN HEMTs Ray Holzworth (30 min)
  - Uniformity Issues and Etching of AFRL HEMTs Pat Jones (15m)
  - Optical Pumping for Analysis of Deep Level Traps in HEMTs Pat Jones (15 min)
- 10:00 Break
- 10:15 Materials Characterization II
  - CL and Micro PL Characterization of AlGaN/GaN HEMTs (15 min) Danny Zeenberg
  - TEM imaging, analysis and holography for III-nitride HEMT devices (30 min) Dave Smith
- 11:00 Break
- 11:15 Simulation
  - Electrothermal Modeling – Michelle Griglione (15min)
  - Electromechanical Degradation – David Horton (15min)
  - Electro-thermal-mechanical modeling – Erin Patrick (15min)
- 12:00 – Lunch, Wrap Up

Precompetitive Engineering Scientific Research Focus

- Scientific Understanding of Materials Properties
- Understanding of Electrical Signatures
- Modeling / Simulation of Failure

- Black's Equation Empirically Captured Aluminum Electromigration in 1969
- Subsequent work on
  - Characterization of field, current density, temperature dependence
  - Characterization of mechanical stress
  - Characterization of grain size diffusion along grain boundaries
  - Characterization of etch effects related to grain size
  - Full 3-Dimensional Grain Models

Recent Papers in 2008 and 2009 - 40 years of science based pubs

Scientific Issues and Importance

Inability to model and predict electronic device failure modes from first principles and underpinning physical mechanisms

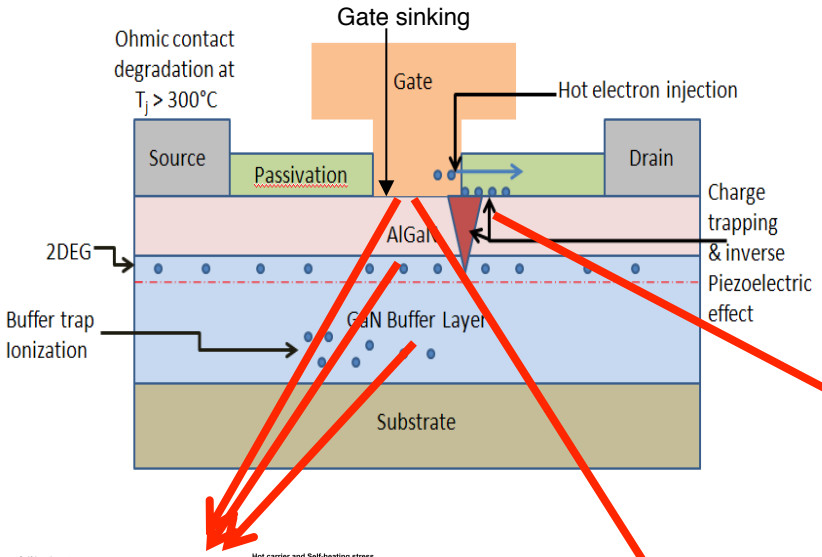
Challenges/ Expected Breakthroughs:

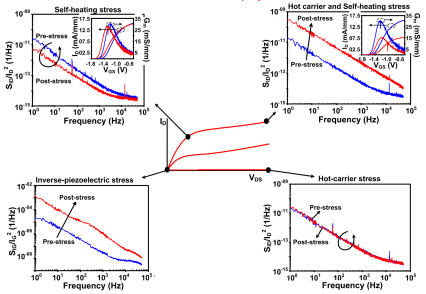
- Lifetime prediction for compound semiconductor device operation is difficult because of poor underlying models
- Elevated temperature testing fails if degradation is driven by field, mechanical stress, hot carriers
- Elevated temperature testing fails if degradation is masked by another mechanism with higher activation energy

Develop new physical modeling capabilities and tools

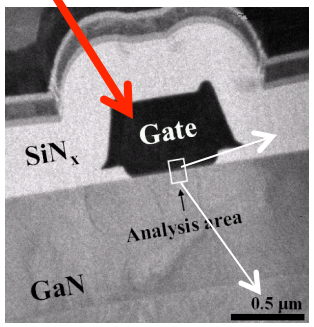
- Accurately keep pace with new material systems
- Changes in operating conditions
- Combining physical models, chemistry, materials science, electrical engineering to develop understanding

Understanding Device Degradation Physics

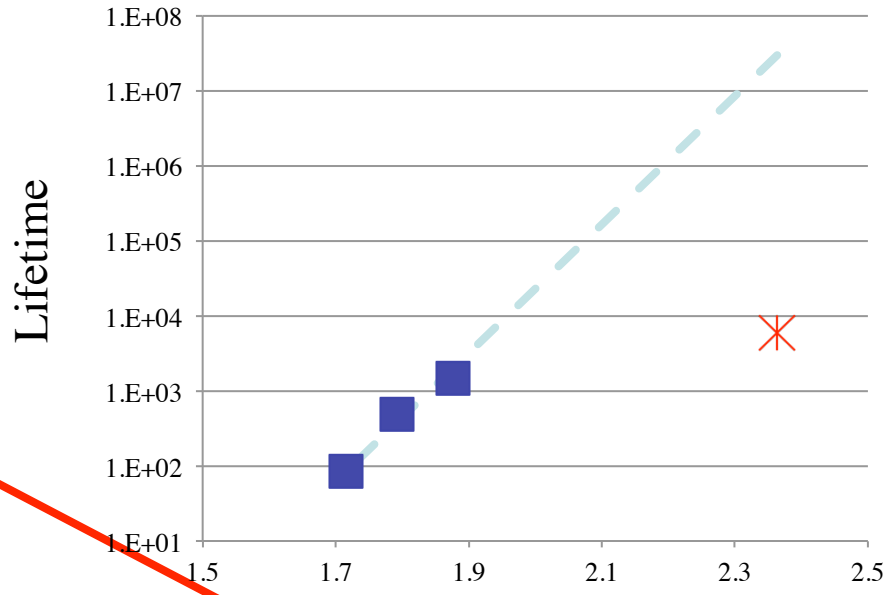


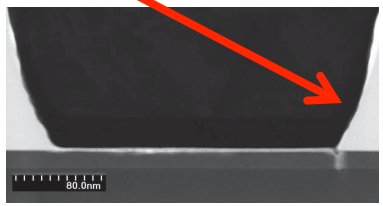


Develop new measurement technique using 1/f noise measurements to model defect energy level and spatial location within devices.



Develop new techniques to study fundamental interfacial chemistry reactions as a function of temperature and electric field

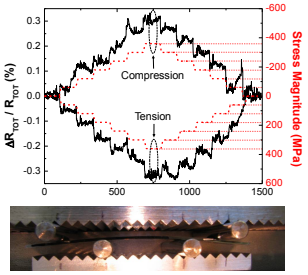


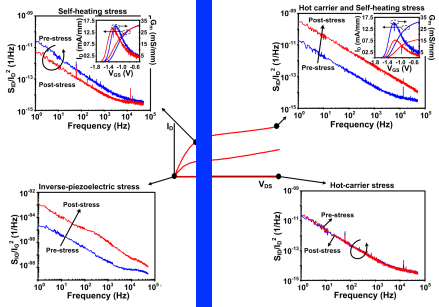


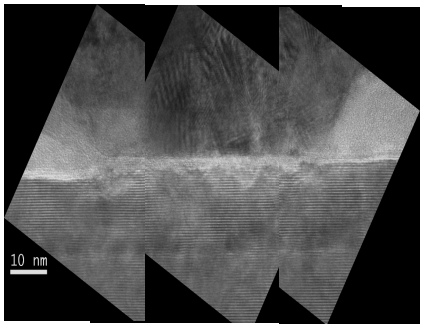
Predict piezo-electric strain induced failure mechanisms by modeling

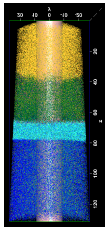
Scientific Approach

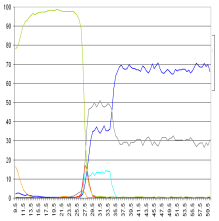
FLOORS









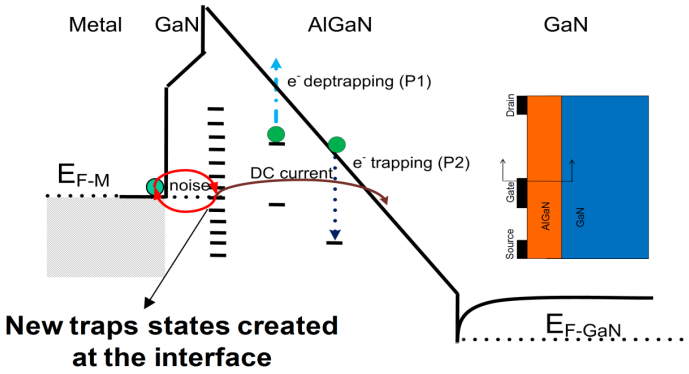


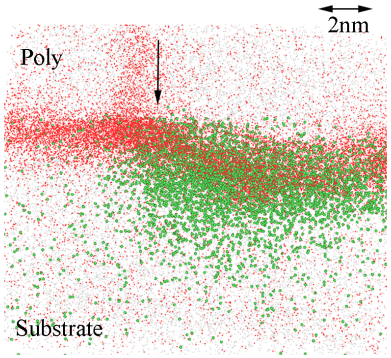
t=0, As Built

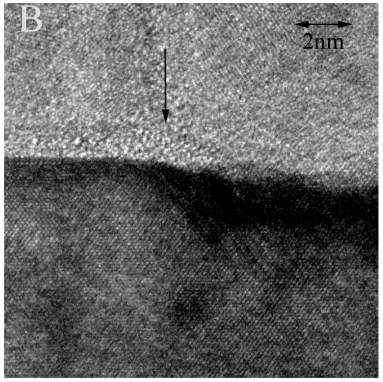
t>0, Degradation

Future Directions

FLOORS
Integrated Electrical, Thermal, Mechanical Simulation







Defect Location and Generation
Driven by Field, Mechanics, Thermal

Material Reaction / Interdiffusion
Driven by Field, Mechanics, Thermal

Unify previous techniques and combine with FLOORS to gain and applicability of physics of failure.

ITAR / Export Control

- Controlled Room in NRF
- Devices kept in locked room and locked cabinet
- Sign in / sign out for experimentation
- ITAR Training Provided

- We can work with corporate devices
- Have controls in place